RothC and JULES modelling of pyrogenic carbon in the Brazilian Amazon

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1. Background

- PyC are resilient, high C content residues produced during the incomplete combustion of biomass during wildfires
- PyC also has the potential to improve soil fertility, suppress GHG fluxes, immobilise pollutants
- PyC can remain in soils for millennia but is often overlooked in C cycling modelling research
- PyC has had limited consideration in preceding Amazon modelling
- The RothC model has previously been used to model PyC in Australian soils (Lehmann et al., 2008)

RothC modelling

A single pool (i.e. IOM) modelling approach with set values for calculating SOC turnover in relation to vegetation cover, C inputs and meteorology.

Fires are simulated at set times via altered C input with corresponding IOM inputs representing PyC.

Research questions:

1. Which modelled fire/PyC conditions show the best alignment with field observations?

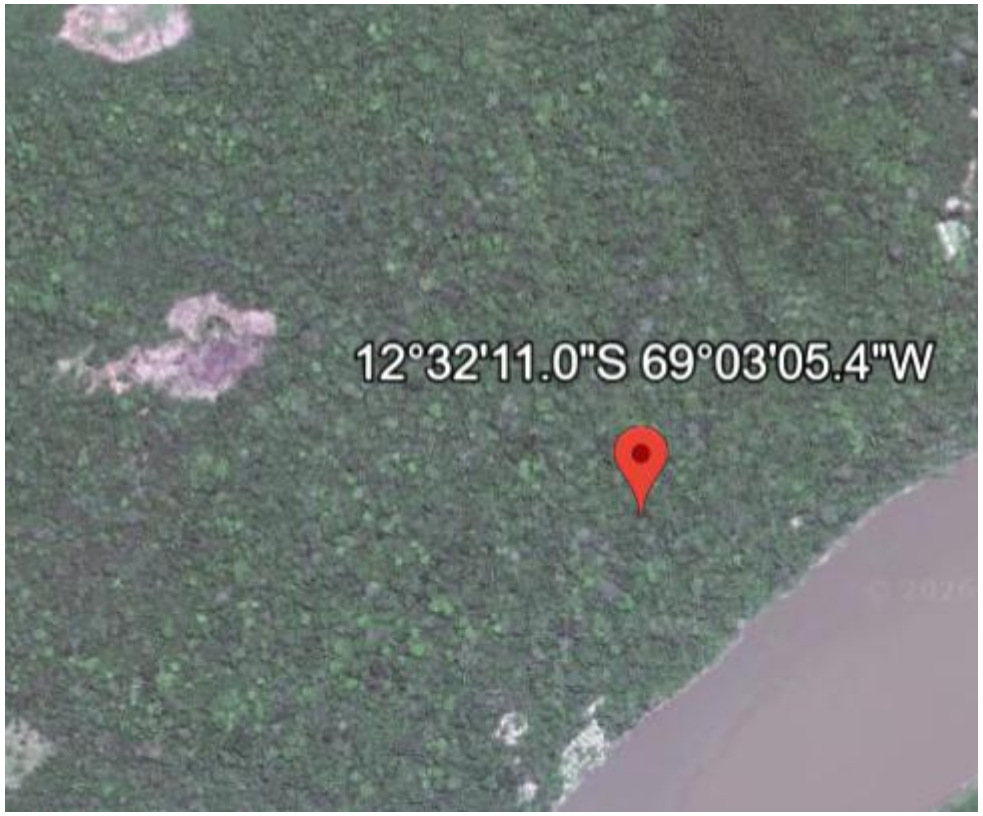
2. What C cycling role does PyC play in future climate scenarios?

2.1. Methods

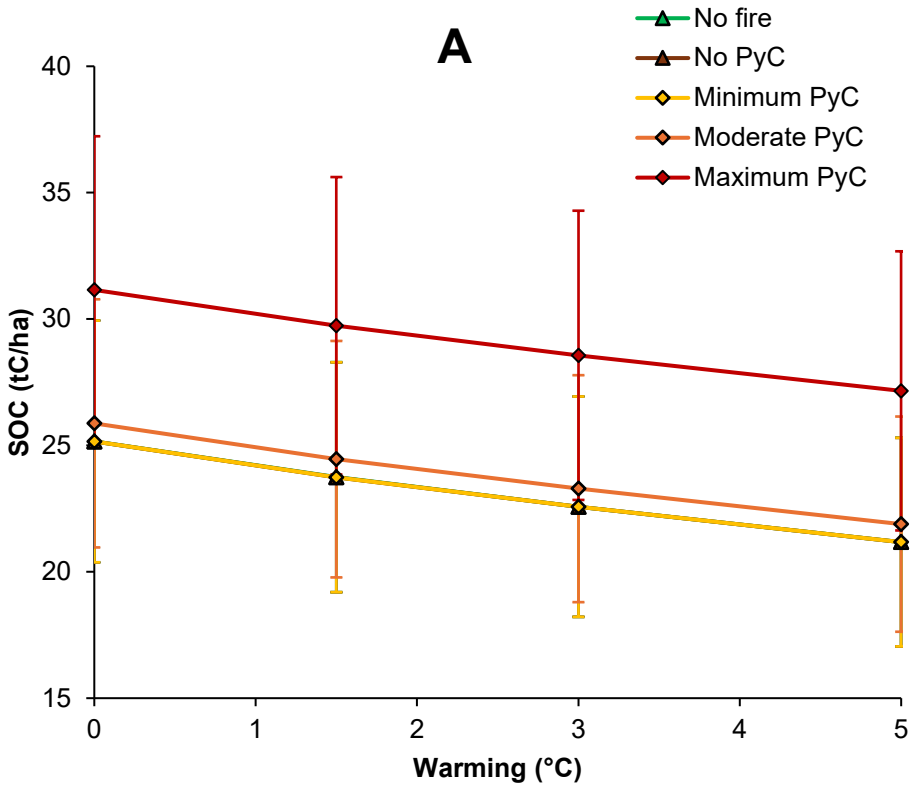
- PyC input as a % of litter / understorey vegetation / <10cm trees
- Site specific clay and meteorological inputs
- Fire timing from site specific charcoal radiocarbon dates
- Model runs with 70% reduction in C input with fire
- PyC modelled as inert organic matter (IOM)
- RQ1: looped until cap or field value are reached / RQ2: PyC yields 1, 10, 25%
- PyC degradation constants: 0.003, 0.0005, 0.0002, 0.0001
- 0, 1.5, 3 and 5°C future warming scenarios

Results – RQ1

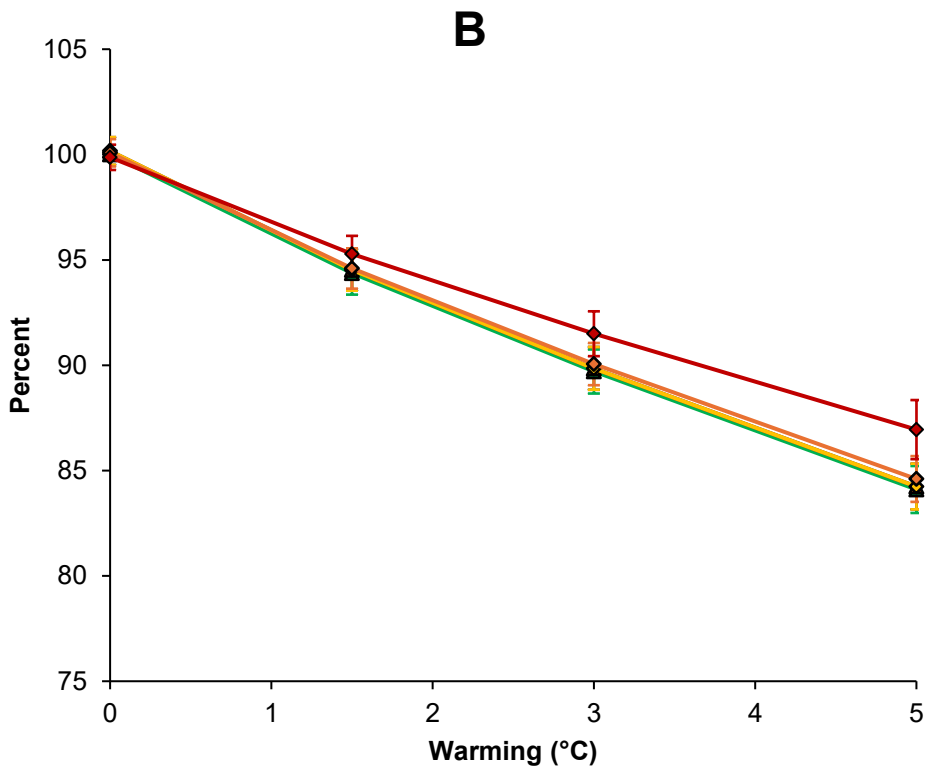
- The strongest model – observed match is achieved with the highest available biomass C scenario with the most recalcitrant PyC
- Maximum possible PyC inputs per fire were 0.126 tCha (10% of the biomass C in that scenario)
- PyC yields were 1.8 – 10 % of pre-fire C
- 23 of 66 sites were underestimated
- The results indicate sources of PyC beyond immediate local fires



Results – RQ2



SOC stocks at 2100



2020 stocks retained by 2100

RothC summary

RQ1

- Reconstructing past PyC production in old growth forests requires the inclusion of biomass beyond just fine litter
- The findings indicate potentially greater burn severity and PyC production rates than often suggested for old growth Amazon forests
- There is a strong need to investigate wider environmental conditions (e.g. aeolian PyC deposition)

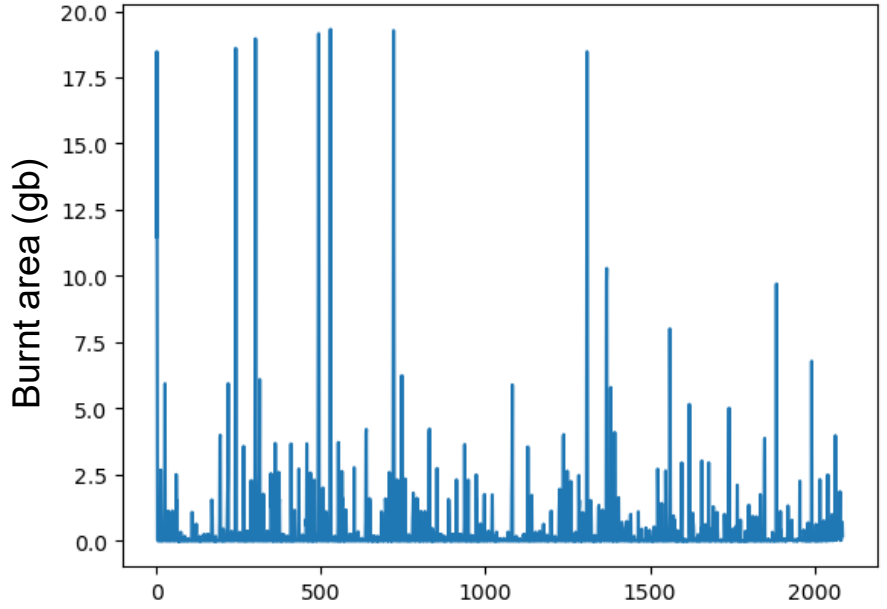
RQ2

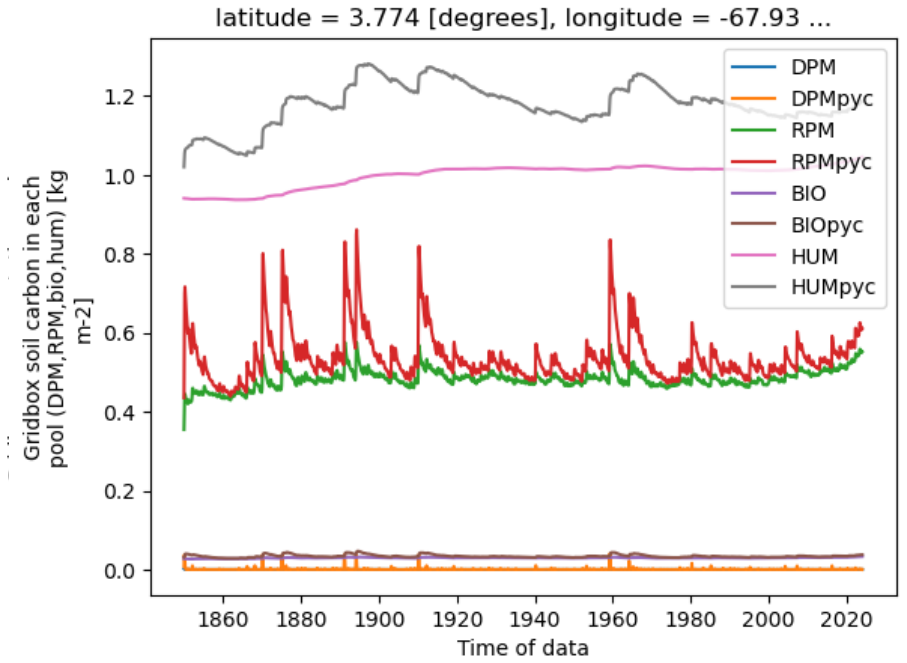
- PyC has the potential to increase SOC stocks by ~3 GtC relative to no-PyC scenarios and is resilient to increased warming conditions
- To achieve these benefits high yields of highly recalcitrant PyC must be produced, indicating the potential for deliberate (e.g. biochar) strategies

JULES

To date:

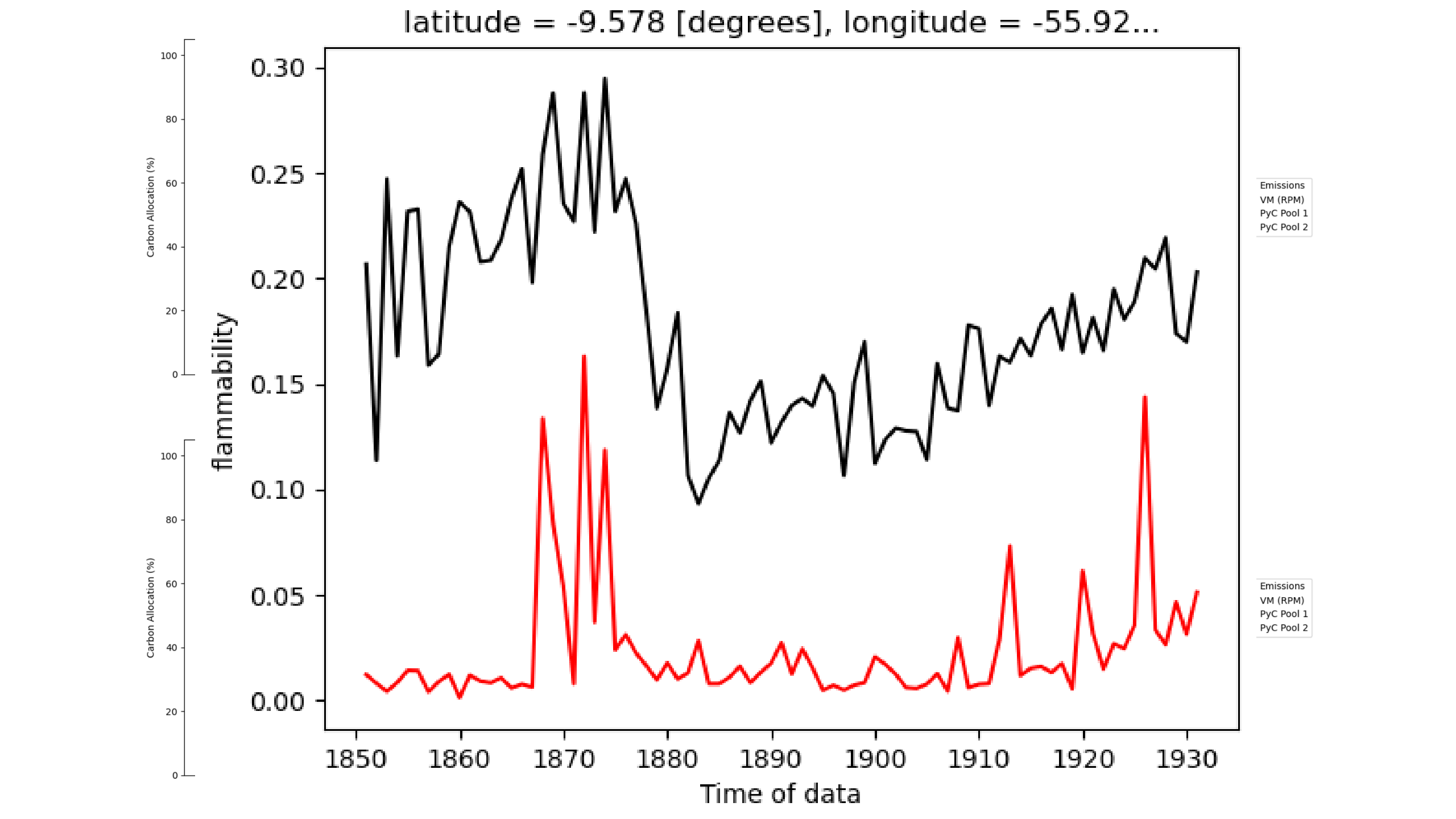
- Point runs at Amazon sites
- Ignition method 1 (constant - 1.5 from humans, 0.17 from lightning)
- Fires produce IOM, RPM and emissions
- Experimented with 25% IOM inputs





Future JULES developments

- JULES will be adjusted to produce PyC yields in relation to model conditions (e.g. fuel flammability), rather than being modelled at set values
- Possible 3 pool modelling approach (e.g. RPM, HUM, IOM)
- Differing PyC composition for different biomass types (e.g. woody vs non-woody PFT components)
- Different ignition approaches will be applied (e.g. prescribed burnt area vs continuous)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0.30
0.25
0.20
0.15
0.10
0.05
0.00
1850
1860
1870
1880
1890
1900
1910
1920
1930
Time of data
Carbon Allocation (%)
100
80
60
40
20
0
Emissions
VM (RPM)
PyC Pool 1
PyC Pool 2
Carbon Allocation (%)
100
80
60
40
20
0
Emissions
VM (RPM)
PyC Pool 1
PyC Pool 2